CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-46

June 16, 1977

1. Name of fault: Malibu Coast fault and related faults.

2. Location of faults: Triunfo Pass, Point Dume, Malibu Beach, and Topanga 7.5 minute quadrangles, Los Angeles County (see figure 1).

3. Reason for evaluation: Part of a 10-year program.

4. List of references:

a) Birkeland, P.W., 1972, Late Quaternary eustatic sea-level changes along the Malibu Coast, Los Angeles County, California: Journal of Geology, v. 80, no. 4, p. 432-448.

b) Bolles, Lawrence, W., 1932, Geology of the Las Flores and Dry Canyon quadrangles: Unpublished M.S. thesis, California Institute of Technology, 57 p., map scale 1:24,000.

c) Campbell, R.H., Blackerby, B.A., Yerkes, R.F., Schoellhamer, J.E., Birkeland, P.W., and Wentworth, C.M., 1970, Preliminary geologic map of the Point Dume quadrangle, Los Angeles County, California: U.S. Geological Survey Open File Map, scale 1:12,000.

d) Campbell, R.H., Yerkes, R.F., and Wentworth, C.M., 1966, Detachment faults in the central Santa Monica Mountains, California: U.S. Geological Survey Professional Paper 550-C, p. C1 to C11.

e) Champeny, J.D., 1961, Paleocene and upper Cretaceous stratigraphy of Santa Ynez Canyon and adjacent areas, Santa Monica Mountains, California: Unpublished M.A. thesis, University of California, Los Angeles, map scale 1:24,000.

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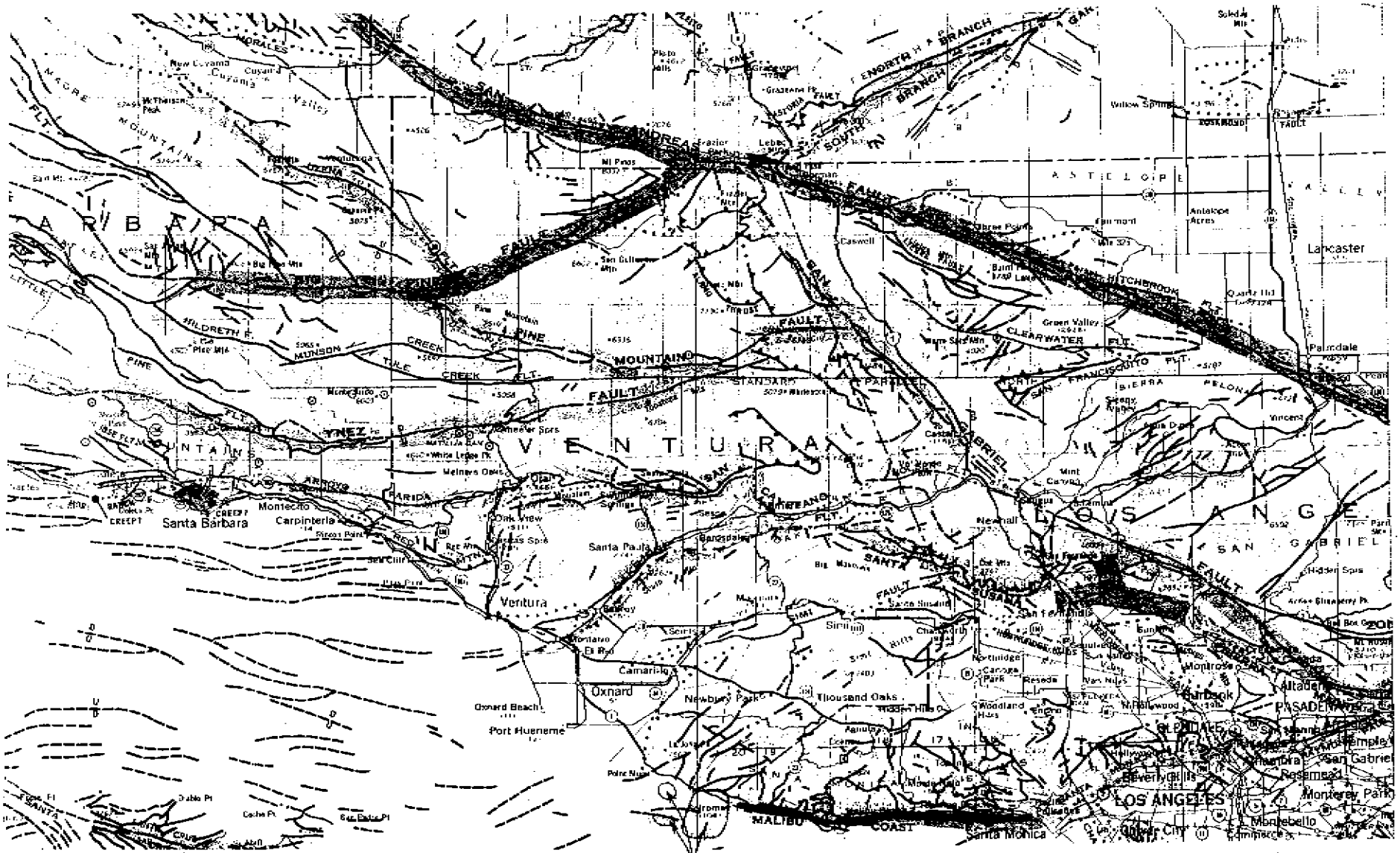
FIGURE 1. General location of the Malibu Coast fault (Jennings, 1975, scale 1:750,000)



f) Cleveland, G.B., and Troxel, B.W., 1975, Geology related to the safety of the Corral Canyon Nuclear Reactor site, Malibu, Los Angeles County, California: California Division of Mines and Geology Open File Report, 36 p., 1 plate (scale 1" = 200').

g) Ellsworth, W.L., Campbell, R.H., Hill, D.P., Page, R.A., Alewine, R.W. III, Hanks, T.C., Heston, T.H., Hileman, J.A., Kanamori, H., Minster, B., Whitcomb, J.H., 1973, Point Mugu, California, Earthquake of 21 February 1973, and its aftershocks: Science, v. 182, no. 4117, p. 1127-1129.

h) Hoots, H.W., 1930, Geology of the eastern part of the Santa Monica Mountains, Los Angeles County, California: U.S. Geological Survey Professional Paper 165-C, 134 p., map scale 1:24,000.

i) Jennings, C.W., 1975, Fault Map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map no. 1, scale 1:750,000.

j) Kelly, Vincent, C., 1932, Geology of the Santa Monica Mountains west of the Malibu Ranch, Ventura County, California: Unpublished M.S. thesis, California Institute of Technology, 55 p., map scale 1:24,000.

Note: Doesn't distinguish between buried and surface faults.

k) Kirkman, L., and Ellsworth, William, 1977, Catalog of earthquakes in the Santa Monica Mountains area for the period February 21, 1973 to December 31, 1973: U.S. Geological Survey Open File Report 77-301, 23 p.

l) Wentworth, C.M., Bonilla, M.G., and Buchanan, J.M., 1973, Seismic environment of the Burro Flats site, Ventura County, California: U.S. Geological Survey Open File Report, 35 p., 2 figures, map scale 1:24,000.

m) Yerkes, R.F., Campbell, R.H., Schoellhamer, J.E., and Birkeland, P.W., 1973, Preliminary geologic map of the unincorporated part of the Topanga quadrangle, Los Angeles County, California: U.S. Geological Survey Open File Map, scale 1:12,000.

n) Yerkes, R.F., Campbell, R.H., Schoellhamer, J.E., and Wentworth, C.M., 1964, Preliminary geologic map and sections of southwest part of the Topanga quadrangle, Los Angeles County, California: U.S. Geological Survey Open File Map, scale 1:12,000.

o) Yerkes, R.F., and Wentworth, C.M., 1965, Structure, Quaternary history, and general geology of the Corral Canyon area, Los Angeles County, California: U.S. Geological Survey Open File Report 864, 214 p., and appendix.

p) Yerkes, R.F., Wentworth, C.M., and Campbell, R.H., 1965, Preliminary geologic map of parts of Malibu Beach and Point Dume quadrangles, Los Angeles County, California: U.S. Geological Survey Open File Map, scale 1:12,000 (accompanies OFR 864).

q) Ziony, J.I., Wentworth, C.M., Buchanan-Banks, J.M., and Wagner, H.C., 1974, Prelimianry map showing recency of faulting in coastal southern California: U.S. Geological Survey, Miscellaneous Field Studies Map MF-585, 15 p., map scale 1:250,000, 3 plates.

5. Summary of available data:

Kelly (1932) first recognized the Malibu Coast fault as a major, dip-slip fault on which there had been movement during the Quaternary. Bolles (1932) felt that the fault was a nearly horizontal, south-dipping fault. Little attention was paid the Malibu Coast fault during the next three decades.

Then, during the mid-1960's, a nuclear power plant was proposed, to be sited near the fault at Corral Canyon. A rather intensive investigation was made by representatives of the U.S. Geological Survey (Yerkes and Wentworth, 1965). At the same time, the California Division of Mines and Geology reviewed the site (Cleveland and Troxel, 1965). These two reports are an interesting contrast, and also probably represent the most definitive data available for any of the faults being evaluated this year.

The Cleveland and Troxel (1965) report culminated a three-month effort to determine the level of activity of the Malibu Coast fault. They concluded that the Malibu Coast fault is a left-lateral, strike-slip fault with a large dip-slip component (p. 10). The fault is characteristically a few inches wide, except at one site where a breccia zone a few feet wide was noted (p. 14). They determined that there ~~was~~ is no evidence of recent fault displacement; there are no fault related geomorphic features present that would indicate that the fault is active, nor ~~were~~ are the terrace deposits (100,000 years old) affected at the site (p. 22).

In direct contrast, the Yerkes and Wentworth (1965) report, which was issued at almost the same time as the Cleveland and Troxel

report, conceded that the terrace deposits (upper Pleistocene) could be faulted, but agrees that there is no topographic expression of any post-Pleistocene displacement (p. 141). Indeed, they state (p. 146) that in one location terrace deposits had been displaced 15 feet vertically. However, "In the Corral Canyon site the youngest known faults are overlain by undisturbed Recent deposits and (or) undisturbed soils that required most or all of Recent time to develop." And they concluded that although these faults (at least seven locations where terraces were cut ~~where~~ were noted) cut deposits older than 25,000 years (C_{14} date), they do not cut deposists younger than 10,000 years (the basal part of the alluvial-colluvial cover).

Yerkes and Wentworth do note that four streams seem to be deflected left-laterally, but that these features are probably due to differential erosion and are pre-Holocene (p. 147-148). They also note that the mountain front may be a fault scarp, but that it predates the earliest terrace deposit (280,000 years old).

Most modern references recognize the Malibu Coast fault as a vertical to north-dipping reverse fault (Yerkes and Wentworth, 1965; Wentworth, et al., 1973; Campbell, et al., 1966; and others). Conflicts arise though with respect to the amount of displacement that has taken place on the fault. Wentworth, et al. (1973, p. 13) felt that thousands of feet of thrust movement had occurred along the Malibu Coast fault, and that late Pleistocene terraces had been displaced 120 feet at one location (but doesn't note where). Campbell, et al. (1966, p. C11) felt that the amount of displacement during the late Pleistocene was limited to a few feet to a few tens of feet. Yerkes and Wentworth (1965, p. 154) noted that the vertical displacement of the base of one

of the upper Pleistocene terraces was at least 18 feet and probably about 35 feet (their locality 5, noted on plate 3 -- this report). This feature, once located between Temescal Canyon and Santa Ynez Canyon and north of the postulated offshore segment of the fault, has since been obliterated. If this were their terrace C (they don't show the site on a detailed map), the oldest terrace (280,000 y.b.p.), then the rate of displacement (using 35 feet) would be about 4 mm. per 100 years, which is quite low. Even using 120 feet (about 14 mm/100 years), the rate is still quite low.

In 1973, a series of earthquakes occurred off Point Mugu (Ellsworth, et al., Kirkman and Ellsworth, 1977). No surface rupture was observed, however, "anomalously large earth tilts" were noted along the Raymond Hill fault (Ellsworth, et al., 1973, p. 1127). The calculated sense of movement of the causative fault was (north over south) reverse, with a small left-lateral component. The calculated fault plane strikes N 60° E and dips 49° N. The hypocenters were mostly from 10 km to 17 km deep (Ellsworth, et al., 1973, p. 1127-1128). Ellsworth, et al., (p. 1128) concluded that "The shocks center at depths well below the north-dipping Malibu Coast fault, in close proximity to...(the projected plane of) the inferred seaward extension of the Santa Monica fault." Thus, it would appear that, although the epicenters are located near the Malibu Coast fault, the hypocenters are not.

Note: No detailed mapping exists for the Malibu fault in the Triunfo Pass quadrangle. The best mapping here appears to be Zlony, et al. (1974).

6. Interpretation of air photos:

While visiting Whittier College, I took about 15 minutes to look at the air photos that cover the Malibu Coast fault (Fairchild flight C3814, numbers 1 through 35, 45, and 46, scale 1:18,000, flown in 1935). I made it a point to look at those localities where offset of late Pleistocene deposits was noted. I did not note any fault-produced topography. (Indeed, I am certain that no fault feature similar to that present on the western end of the Red Mountain fault exists -- see FER-28.)

7. Field observations: None made at this time.

8. Conclusions:

All evidence indicates that, while late Quaternary displacement has occurred on one or more strands of the Malibu Coast fault, no displacement has been demonstrated during the Holocene. Unequivocably, there is no known evidence for Holocene displacement along the Malibu Coast fault. The fault would appear to be well-defined; however, there are many related or sympathetic faults scattered throughout the northern block. In all likelihood, further study (as part of this project) would fail to alter these conclusions. Indeed, it appears that the fault has already been subjected to the most intensive study of any recent fault in the study area, and has the most definitive data available with respect to absence of recent fault rupture.

9. Recommendations:

Under the present project guidelines, the Malibu Coast fault should not be zoned as it does not meet the criteria of "sufficiently active." No further work appears necessary on the part of the Fault Evaluation Project staff regarding this fault.

10. Investigating geologist's name; date:

Theodore C. Smith

THEODORE C. SMITH
Assistant Geologist
June 16, 1977

I agree with the recommendations.
EMK
7/7/77